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STORAGE

FURTHER NOTES ON *PEMPHERES AFFINIS*, FST (THE COTTON STEM WEEVIL)

BY

E. BALLARD, B.A., F.E.S

Government Entomologist, Madras

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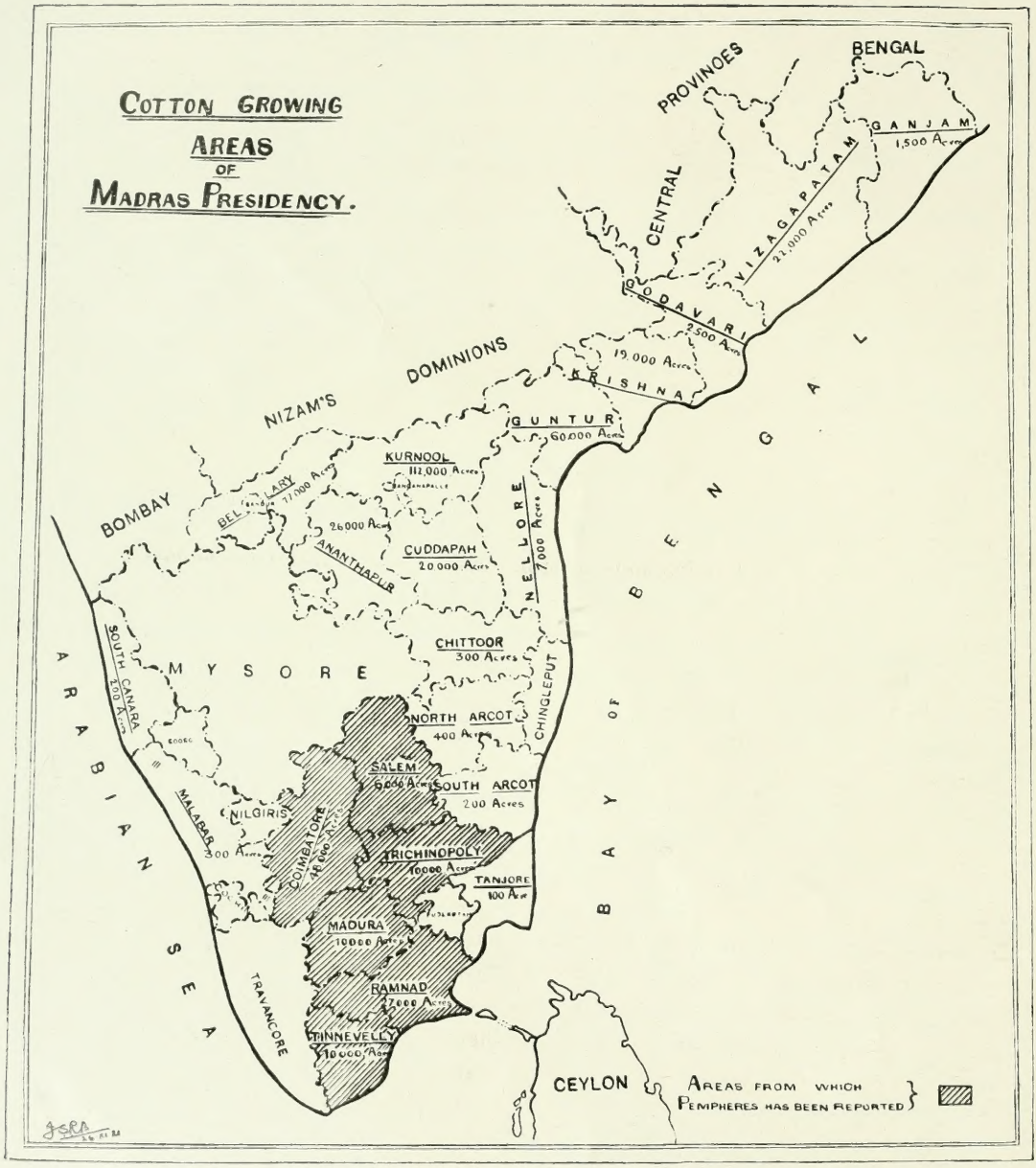
COTTON GROWING
AREAS
OF
MADRAS PRESIDENCY.
BENGAL
PROVINCES
CENTRAL
GANJAM
1,500 Acres
VIZAGAPATAM
21,000 Acres
GODAVARI
2500 Acres
19,000 Acres
KRISHNA
DOMINIONS
NIZAM'S
GUNTUR
60,000 Acres
KURNOOL
112,000 Acres
BELLARY
77,000 Acres
BOMBAY
26,000 Acres
ANANTHAPUR
CUDDAPAH
20,000 Acres
NELLORE
7000 Acres
CHITTOOR
300 Acres
MYSORE
SOUTH CANARA
200 Acres
NORTH ARCOT
400 Acres
CHINGLEPUT
SALEM
6000 Acres
SOUTH ARCOT
200 Acres
NILGIRIS
300 Acres
MALABAR
COIMBATORE
10,000 Acres
TRICHINOPOLY
10000 Acres
TANJORE
100 Acres
MADURA
10000 Acres
RAMNAD
7000 Acres
TINNEVELLY
10000 Acres
TRAVANCORE
ARABIAN SEA
BAY OF BENGAL
CEYLON
AREAS FROM WHICH PEMPHERES HAS BEEN REPORTED

FURTHER NOTES* ON *PEMPHERES AFFINIS*, FST. (THE COTTON STEM WEEVIL).

BY

E. BALLARD, B.A., F.E.S.,

Government Entomologist, Madras.

(Received for publication on the 3rd May, 1922.)

THE Cotton Stem Weevil has attained some notoriety in South India as a pest of exotic and indigenous cotton, and was at one time looked upon as the most serious enemy of the *raiyat* in the cotton-growing tracts.

Further experience goes to show that it is only in exceptional cases that it can be regarded as a pest of the first order, and it certainly cannot now be compared with such insects as *Platyedra gossypiella* or *Earias fabia* and *E. insulana*. In 1911-12, when *Pempheres* first came into prominence, it was undoubtedly a much more serious pest than it is now. It is probable that both Cambodia and indigenous cotton are becoming immune, or at least resistant to *Pempheres*.

The known distribution of *Pempheres* was until recently peculiar, as it was reported only from Pusa and Coimbatore. In another part of this paper are given the localities in South India in which it is now known to attack cotton, the exceptions being North and South Malabar where no cotton is grown. The question arises as to whether *Pempheres* has spread from some centre such as Coimbatore or if it is a matter of its having only within recent years taken to attacking cotton and, having once acquired a taste

* Many of the notes from which this paper is compiled were made by Messrs. P. V Isaac and T. V. Subramaniam.

for cotton from the exotic Cambodia cotton, has now spread to country varieties. Again, it might simply have been overlooked. As no stem weevil has been found in those localities where cotton growing has only recently been taken up, it is probable that *Pempheres* is only gradually acquiring the taste for cotton. *Pempheres* is by no means confined to cotton or even to Malvaceæ for its food-plants and has been found breeding in or feeding on many different plants. A pest with so many alternate food-plants, and one which is moreover a borer, is difficult to deal with, as it will always be able to carry over from one cotton crop to another. Cotton, too, is attacked at a very early age and *Pempheres* does not have to wait for bud or boll formation as is the case of *Platyedra*. It is not surprising then in the circumstances that the dead season decreed by the Pest Act between one cotton crop and another appears to have had little or no result in reducing the loss, such as it is, which is due to *Pempheres*, while in the case of *Platyedra* it has been so successful. According to laboratory results the adult weevil is long-lived (36 days) and this again would assist it to tide over a time when there is no cotton crop in the ground.

Remarks on the general habits of *Pempheres* are to be found in Lefroy's *Indian Insect Life*, Fletcher's *Some South Indian Insects* and in the *Madras Year Book* for 1918 (T. V. Ramakrishna Ayyar). This latter paper gives a general description of the different stages of the life-history and describes the nature of the damage done. In that paper it is stated that the stem weevil will reduce the normal out-turn of the cotton crop from 15-20 per cent. No figures are given in support of this statement, and, however accurate it may have been some years ago, it is certainly not the case now. Results obtained in 1920-21 by the Cotton Specialist at Coimbatore, and further observations in the field, make it extremely doubtful that anything approaching this amount of damage is done. There appears to be no difference in the yield from plants attacked by *Pempheres* and those which are free. In certain cases where plants lodge boll production is reduced, but these cases are the exception rather than the rule and an adult plant is rarely killed.* The chief loss is caused to seedlings which almost invariably succumb to stem weevil attack. There is some indication that certain strains of Cambodia are less liable to attack in their early stages than others, and among indigenous varieties *Karunganni* (*G. indicum*) is much less affected than *Uppam* (*G. herbaceum*).

* For an exception to this rule is the report from Messrs. Harvey in another part of this paper.

PEMPHERES AFFINIS.

EXPLANATION OF PLATE XXIII.

Pempheres affinis.

Fig. 1. Cotton plant showing swellings on the stem caused by the grub boring inside, and also an egg laid just under the bark.

„ 2. Egg shown separately with thin layer of the bark removed, magnified.

„ 3. The weevil grub .. × 10.

„ 4. The pupa .. × 12.

„ 5. The adult weevil, dorsal view × 14.

„ 6. „ side view × 14.

„ 7. An infested stem cut open to show grubs and pupæ inside.

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" 5. The adult weevil, dorsal view × 14.

" 6. " " side view × 14.

" 7. An infested stem cut open to show grubs and pupæ inside.

The Bourbon-Cambodia cross is not so readily attacked as Cambodia. Work along the lines of finding a *Pempheres*-resistant strain is only in its infancy and is still in progress, but the results obtained in 1920-21 which are to be given in another paper show that there are distinct possibilities in this direction. Whether such resistance or unattractiveness can be combined with other desirable qualities in Cambodia cotton remains to be seen.

The present paper embodies some further facts in the life-history (Plate XXIII) of *Pempheres affinis* and the results obtained in 1920-21 from the study of the different degrees of infestation in the Cotton Specialist's selections at Coimbatore. The present distribution of *Pempheres* as far as it is known is shown in the map which forms the frontispiece (Plate XXII). Further inquiries will probably add greatly to the area of distribution now shown.

Life-history notes.

In the paper on *Pempheres affinis* in the *Madras Year Book* 1918, the following are given as the average periods for the different stages of the life-history :—

Egg	10	days.
Larva	35	,,
Pupa	12	,,
Adult	30	,,

Further investigation has shown (under laboratory conditions) that, although the egg period remains constant at from 6–8 days, depending perhaps on the time of the year, the length of the larval life is variable and lasts from 35–57 days. The pupal period is from 9-10 days. After completing its development the adult remains from 2–5 days in the stem. Adults have lived in the Insectary for 36 days. They may live longer than this in nature. *Pempheres* is very free from natural enemies, but a Chalcid has been reared which parasitizes the larva, and a fungus has been found which destroys all stages except the egg. Work on this is not yet complete but it would appear to be a much more effectual control than the Chalcid.

Differentiation of male and female.

In the original description of *Pempheres affinis* no differentiating characters are given for the males and females. In the paper on the stem weevil (*Madras Year Book*, 1919), it is mentioned that there are a pair of spines above the coxal cavity of the forelegs. These spines do not exist in the female and

are represented only by tubercles; it is only in the males that the spines are developed (Fig. 1). Judging from observation of beetles in the laboratory, the female is much less active than the male who runs continually over the food-plants while the female does not move about nearly so much. During copulation the male grasps the female with the middle pair of legs

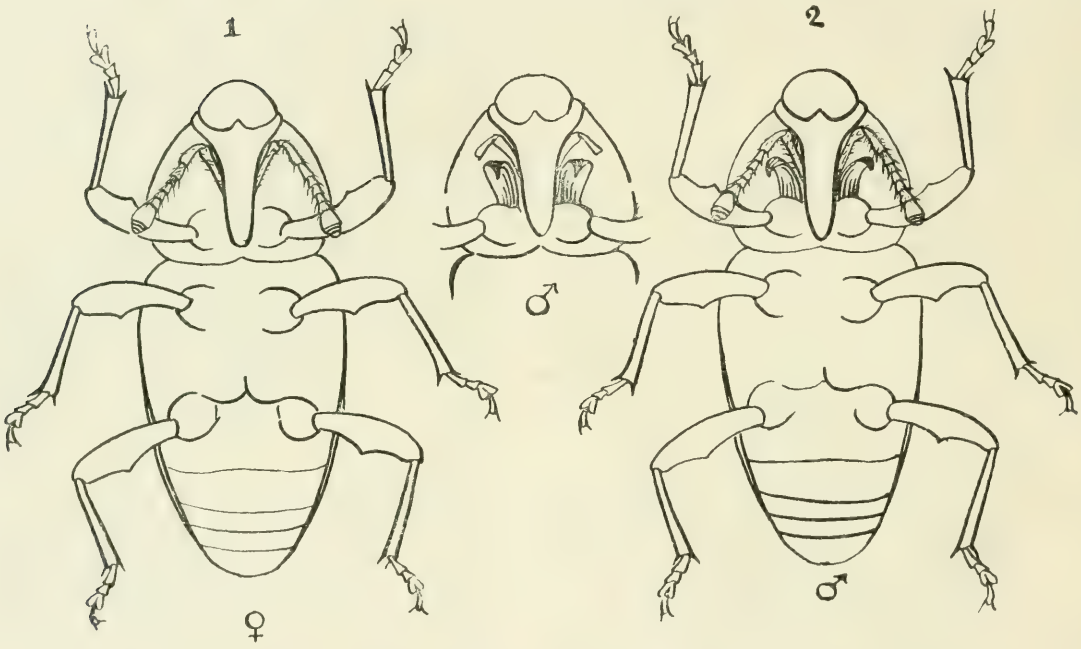

FIG. 1. Ventral aspect of male and female of *Pempheres affinis* and the coxal spines of the male.

and continually strokes her head and antennæ with his forelegs and antennæ. Sometimes this stroking process becomes a violent tattoo. The female also at times strokes her head with her forelegs, or rubs the tarsi together, the forelegs being held out in front. In the case of one pair which was under observation, the male ceased his stroking and the female after two or three minutes became restive but was immediately calmed down again on the male renewing his attention. Copulation lasts as a rule about five minutes.

TABLE I.

Egg period.

Date of laying	Date of hatching	Length of period in days
18-19- VI-19	25-26- VI-19	7
19-20- VI-19	27-28- VI-19	8
27- VI-19	4-VII-19	7
28-29- VI-19	5-6-VII-19	7
28-29- VI-19	6-7-VII-19	8
9-10- VI-19	16-17-VII-19	7
11-12-VII-19	18-VII-19	7
15-VII-19	23-VII-19	8
17-VII-19	23-VII-19	7
17-VII-19	24-VII-19	6
18-VII-19	25-VII-19	8
18-VII-19	26-VII-19	..
18-VII-19	26-VII-19	6
19-VII-19	26-VII-19	7
19-VII-19	26-VII-19	7
19-VII-19	26-VII-19	8
14-VII-19	20-VII-19	7
20-VII-19	27-VII-19	7
21-VII-19	29-VII-19	7
21-VII-19	29-VII-19	6
22-VII-19	29-VII-19	7
22-VII-19	30-VII-19	8
23-VII-19	31-VII-19	8
23-VII-19	31-VII-19	8
24-VII-19	31-VII-19	7
25-VII-19	31-VII-19	6
26-VII-19	2-VIII-19	6
27-VII-19	5-6-VIII-19	8-9
28-VII-19	6-VIII-19	9
28-VII-19	3-VIII-19	6
28-VII-19	3-VIII-19	6
28-VII-19	6-VIII-19	9
29-VII-19	6-VIII-19	8
29-VII-19	6-VIII-19	8
8-9-VIII-19	17-VIII-19	8
12-VIII-19	20-VIII-19	8
15-VIII-19	23-VIII-19	8
15-16-VIII-19	21-22-VIII-19	6
8-9-VIII-17	17-VIII-17	9

This gives an average of just over seven days from the time the egg is laid until the time of hatching.

LENGTH OF LARVAL LIFE.

The period occupied by the larval stage varies considerably as the accompanying Table II shows. This may be natural or may be due to laboratory conditions. To facilitate observation, larvæ were kept in pieces of cotton stem or stem of another food-plant (but generally cotton) and these stems placed in culture solution to keep them fresh. Grubs had often to be transferred

from one piece of stem to another, and were often looked at to ascertain the exact time of pupation. All this might upset the normal course of the larval existence. It is difficult in the case of borers to be certain that the environment in which they are kept is an exact enough reproduction of natural conditions.

TABLE II.

Length of larval life.

Date of hatching	Date of pupation	Length of period in days
5-6–VII–19	21–VIII–19	41
5-6–VII–19	26–VIII–19	51
6-7–VII–19	17–VIII–19	31
6-7–VII–19	19–VIII–19	33
6-7–VII–19	31–VIII–19	54
6-7–VII–19	2–IX–19	56
23–VII–19	29–VIII–19	37
23–VII–19	27–VIII–19	36
23–VII–19	2–IX–19	40
26–VII–19	27–VIII–19	32
26–VII–19	9–IX–19	44
27–VII–19	28–VIII–19	31
27–VII–19	4–IX–19	Doubtful when actually became pupa.
29–VII–19	2–IX–19	36
29–VII–19	2–IX–19	36
31–VII–19	2–IX–19	Pupation probably on 1–IX–19.
31–VII–19	9–IX–19	40
31–VII–19	13–IX–19	44
6–VIII–19	22–IX–19	47
6–VIII–19	22–IX–19	47
13–VIII–19	22–IX–19	40
5-6–VIII–17	6–IX–17	32
5-6–VIII–17	10–IX–17	36
5-6–VIII–17	6–IX–17	32
17–VIII–17	11–X–17	55
1-2–VIII–19	9–IX–19	38
1-2–VIII–19	30–IX–19	59
31–VII–19—2–VIII–19	9–IX–19	38-40
27-28–VI–19	21–VIII–19	54
28-29–VI–19	17–VIII–19	50
28-29–VI–19	19–VIII–19	52

This table gives an average of about 42 days from time of hatching to time of pupation.

PUPATION.

This takes place in a chamber prepared by the larva which is generally deep in the stem. Before pupation the larva usually cuts a passage for the adult weevil to the exterior, leaving only the bark to be nibbled through when the beetle finally emerges. The beetle usually stays 2–5 days in the pupal chamber before coming out.

TABLE III.

Pupal period.

Date of pupation	Date of becoming adult	Length of period in days
(?)16–VII–20	22–VII–20	6
19–VII–20	28–VII–20	9
9–X–18	19-20–IX–18	10
10–IX–17	20–IX–19	10
6–IX–17	15–IX–17	9
13–IX–19	22–IX–17	9
30–IX–19	9-10–X–17	9-10
11–X–17	22–X–17	11
14–X–17	24–X–17	10

An average of 9-10 days.

Pairing generally takes place a day or two after emergence from the attacked plant and egg-laying begins two or three days afterwards. Pairing occurs more than once.

Attempts to obtain egg-laying records have not been attended with much success. A maximum of 30 from one pair is recorded, but, judging from the rapid rate of increase in the field and the large number of larvæ sometimes found in one stem, it is quite possible that far more than 30 are laid in nature by one female.

EGG-LAYING RECORDS.

Freshly emerged male and female.

Caged	25–VII–19	first egg laid	26–VII–19	♀	lived	17	days	laid	19	eggs
Emerged	18–VI–19										
paired	19–VI–19 and	„	26–VI–19	♀	„	21	„	„	20	„
again on	23–VI–19	„	26–VI–19	♀	„	12	„	„	7	„
Brood of	29–VI–19										
Pair (1)	Found in cop.										
	30–VI–19	„	2–VII–19	♀	„	15	„	„	3	„
(2)	„ „	„	„	♀	„	10	„	„	11	„
(3)	„ „	„	„	♀	„	9	„	„	11	„
(4)	„ „	„	„	♀	„	10	„	„	15	„

First egg laid 3 days after emergence and two days after coupling.

29–VI–19 freshly emerged ♀ and two ♂ ♂

Paired	2–VII–19	First egg laid	5–VII–19	♀	lived	29	days	laid	20 eggs.
♀ of	10–VII–19	,,	14–VII–19	♀	,,	20	,,	,,	22 ,,
♀ of	11–VII–19	,,	12–VII–19	♀	,,	14	,,	,,	6 ,,
♀ of	11–VII–19	.. ..	..	♀	,,	22	,,	,,	30 ,,
♀ of	12–VII–19	.. ..	..	♀	,,	21	,,	,,	12 ,,

The length of life from egg to adult.

	Date of laying	Date of death	Length of period in days
(1)	8-9–VII–17	6–XI–17	87
(2)	8-9–VII–17	18–XI–17	99
(3)	27–VII–17	12–X–17	77
(4)	27–VII–17	24–X–17	89

It will be seen at least two of these individuals would have been able to survive the dead season for cotton which lasts from 1st August to October or the beginning of November depending on whether the north-east monsoon bursts late or early. The average life from egg to time when adult is ready to lay would be just over two months.

By examining a certain number of stems weekly and noting the proportion of larvæ to pupæ contained in them it was hoped that an indication would be given of the number of broods in the year, supposing that any definite broods existed. Plate XXIV, fig. 1, shows results obtained in 1919-20 and is self-explanatory.

Plate XXIV, fig. 2 shows the same thing for 1920-21 except that in this case the matter is gone into in greater detail and larvæ found were grouped under three headings:—those under 2 mm., those between 2 and 5, and those over 5 mm. It will be seen that there was a high proportion of freshly hatched larvæ (*i.e.*, under 2 mm.) in February, April, the middle of May and first half of June. Examination of stems pulled up after the season (*i.e.*, after 1st August) also showed a high proportion of young larvæ (not shown in graph).

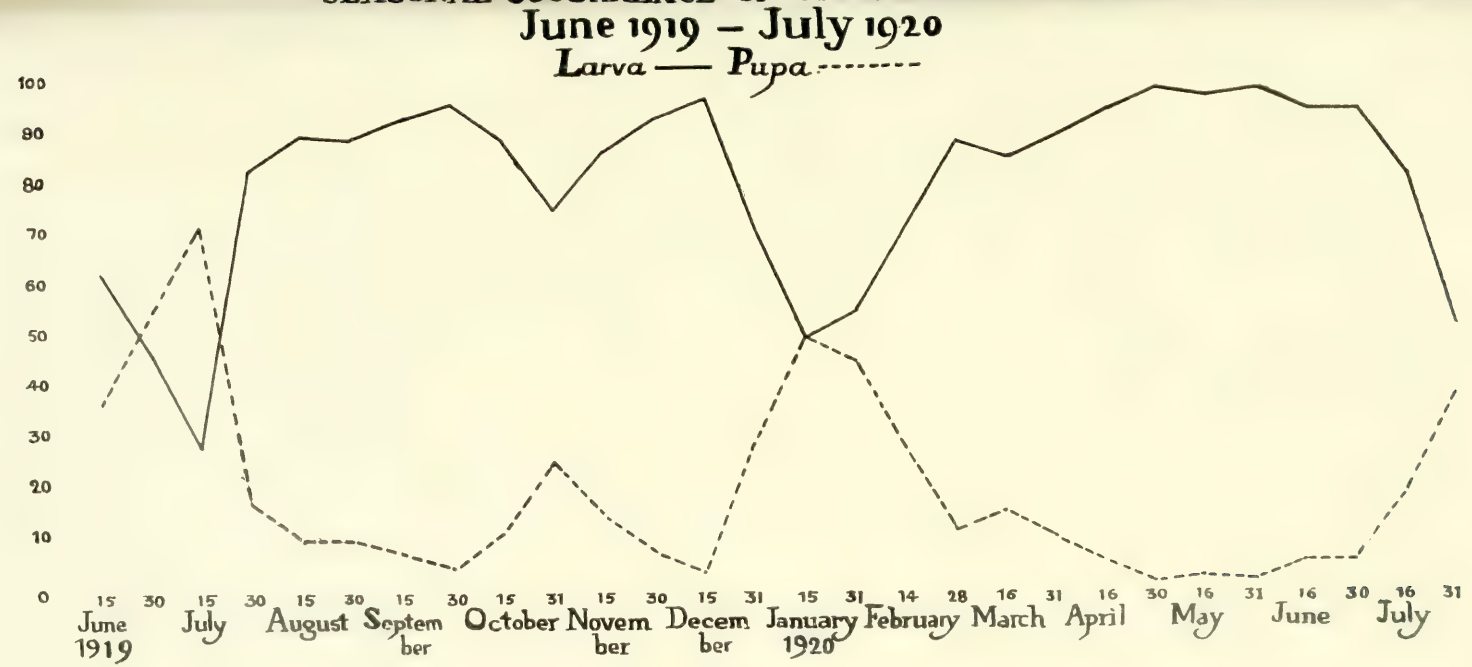

Fig. 1.

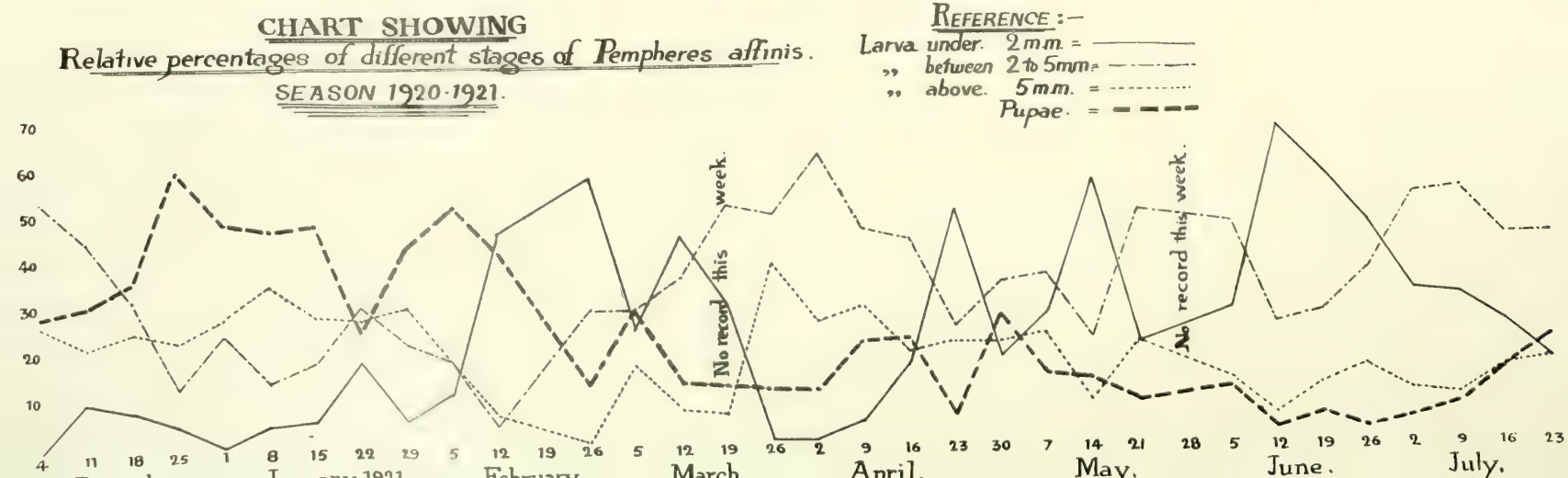

PLATE XXI

DEGREE OF INFESTATION OF PLANTS IN THE FIELD.

Once any field is attacked the number of infected plants increases rapidly throughout the season and infestations of 90 per cent. are common by the end of July.

TABLE IV.

	Date of examination	Percentage of attack
Field No. 39, Central Farm. Sown October (?), 550 plants in one row	25–XI–19—10–XII–19	10·5
	16–VII–20	92·3
Field No. 23. Sown 25–IX–19	14–XI–19	10·8
Field No. 19B, 403 plants. Sown 6–X–19 ..	25–XI–19—10–XII–19	10·6
	16–VII–20	94·0
Field No. 15 A & B. Sown Oct. ? 579 plants ..	25–XI–19—10–XII–19	10·7
	16–VII–20	88·5
Field No. 54, 1,062 plants. Sown 29–IX–19 ..	25–XI–19—10–XII–19	15·8
	16–VII–20	88·5
Field No. 20, 866 plants. Sown 30–IX–19 ..	25–XII–19	8·02
	14–VII–20	90·3

Plants are attacked three weeks after germination and are then almost invariably killed. It is while the crop is in the seedling stage that most damage is done.

Pempheres ATTACK AT VIRUDUPATTI IN 1921.

In April 1921, a report was received from the Agent for Messrs. Harvey, at Virudupatti in Tinnevelly District, that a new pest was playing havoc with the cotton in that district. Investigation showed that the pest in question was the stem weevil. The centre of infection appeared to be Virudupatti town. Examination of plants taken at random showed that the infestation was 65–75 per cent. on the north and east of the town and gradually decreased to 4 per cent. and 2 per cent. in fields further away. The result of examination of a number of plants is given in

the diagram attached (Fig. 2). It will be seen that the infested area was not large and that infection appears to spread from a definite

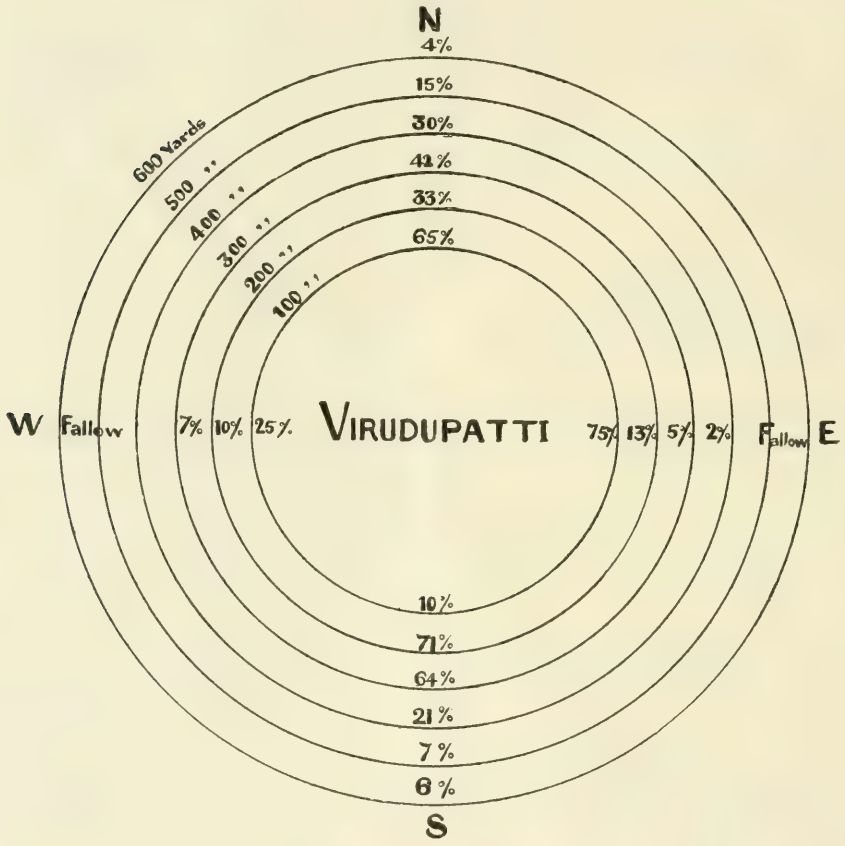

FIG. 2. DIAGRAM SHOWING PERCENTAGES OF PEMPHERES INFESTATION 1921 ROUND ABOUT VIRUDUPATTI.

centre. The mortality was high, 29 per cent. of 200 attacked *Uppam* plants being killed. Curiously enough, Cambodia in the same area, while showing a higher percentage of attack (69 per cent.), showed a smaller percentage of deaths (11·5 per cent.). It was observed that the *Uppam* plants had not produced bolls whereas the Cambodia had done so.

Powers of survival in dry stems.

Infested cotton plants pulled up and kept in the laboratory continued to produce beetles for some time. One interesting point was that, as the stems dried up, the weevils which emerged became smaller and smaller. A pair of these dwarf weevils was mated and the offspring successfully reared. Owing to an oversight the parents were put into the general collection unmarked so that their exact measurements could not be made, but the result of their union was larger than its parents. These observations tend to show that when at the end of the season cotton plants are pulled up and stacked in or near cotton fields although they are drying up, weevils will emerge from them for some time afterwards and help to carry on the race until the next crop is in a fit state to be infested. It would however seem that, if cotton stems are dried in the sun before being stacked, grubs are not able to complete their development. This way of killing off grubs and beetles at the end of the season is of course dependent on sunny days, whereas in July and August when plants should be pulled up there are frequent showers and the days are often cloudy.

Cotton plants pulled out on 29th July, 1920, and kept in a cage in the Insectary continued to produce weevils up to 13th September, 1920.

From another lot beetles continued to emerge for one month, *i.e.*, up to 30th August, 1920.

From another lot pulled up in the hot weather, 20th to 30th May, 1919, dwarf weevils emerged on 29th June, 1919, normal weevils came out at intervals, up to 13th July, 1919, when another dwarf was found. One more dwarf came out on 21st July, 1919, after which date no more emerged.

On 25th June, 1917, infested plants were brought into the Insectary. Weevils continued to come out from them up to 28th August, 1917.

Plants pulled up on 29th July, 1919, and kept in the sun produced no weevils. From another lot of 100 stems dried in the sun for ten days no weevils emerged.

Food-plants other than cotton.

It has already been stated that *Pempheres* has many other food-plants than cotton. A list of these is given below. *Pempheres* has been bred from all of them with the exception of those marked*, from which only adults have

been caught. Weevils found on *Ficus religiosa* were pairing but were not observed to lay.

Hollyhock.
Hibiscus rosasinensis.
Hibiscus cannabinus (*Gogu*)
Hibiscus esculentus (*Bhindi*)
Abutilon indicum
Gossypium religiosum
} Malvaceæ.

Corchorus olitorius. Tiliaceæ ; a very common plant in the fields.
**Calotropis gigantea.*
**Ficus religiosa.*
**Nim* (*Melia Azadirachta*).
Sida spinosus.
Dombeya angulata.
Tirumphetta.

It will be seen that *Pempheres* has many alternative plants to fall back on when the cotton crop fails, which must make any attempt to starve it out a matter of extreme difficulty.

Distribution.

The map which forms the frontispiece shows the distribution in South India so far as it is known at present. This map also shows the cotton areas of Madras and is taken from the Cotton Committee's Report, 1919. *Pempheres* has been collected from the following districts in South India :—Coimbatore, Trichinopoly, Ramnad, Madura, Salem, North and South Malabar, Tinnevelly. No reliable records from the north of the Presidency have yet been received.

Susceptibility of different strains to *Pempheres* attack.

Apart from the apparent difference in susceptibility to *Pempheres* attack shown by different strains of Cambodia, to be considered hereafter (in another paper) the following notes are not without interest. *Uppum* and Cambodia appear to be equally liable to attack but as a rule *Uppum* is more resistant. On the other hand *Karunganni* appears to be far less attractive to the stem weevil as the following figures show. (This case is quite typical) : —

Uppam .. 100 stems examined 26th April, 1921 —58 attacked.
Karunganni .. 100 „ 26th April, 1921 —14 attacked.

In 1920 two plots were sown side by side in the Insectary compound. One contained *Uppam* and one Cambodia. As plants lodged they were pulled up. The photograph of the two plots shows that *Uppam* is much more

Fig. 1. Uppam plants infected with *Pempheres* but not lodged.

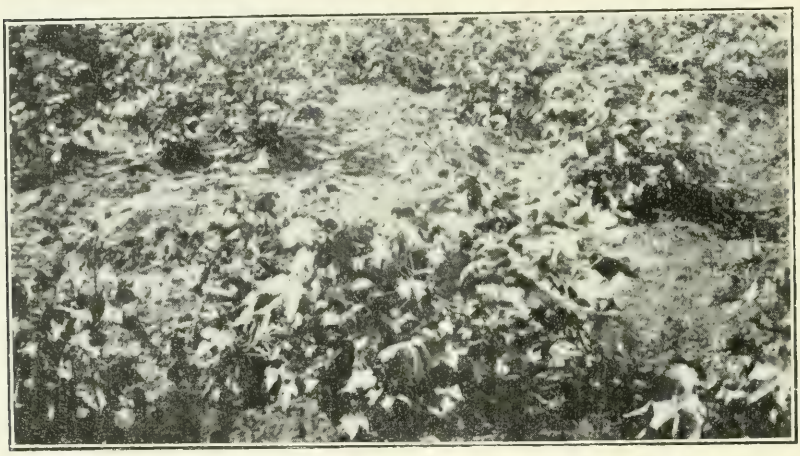

Fig. 2. Patches due to lodging of Cambodia plants.

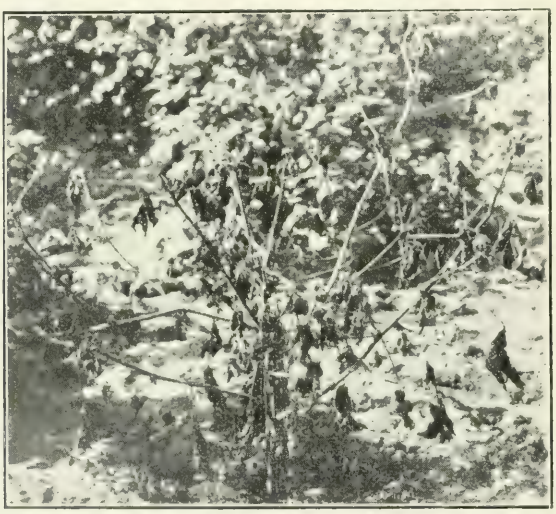

Fig. 3. Cambodia plant killed by *Pempheres*.

resistant than Cambodia, in which plot there are many gaps. The degree of infestation was the same. It might be noted in passing that the proportion of Cambodia plants which lodged was very high compared with the amount observed in the field (Plate XXV).

As regards the attractiveness or otherwise of different strains of Cambodia the following results from counts made on Government seed farms and in the fields of neighbouring *raiyats* are not without significance. The seed farms belong to *raiyats* but the seed is supplied by the Government. The other *raiyats'* fields were sown with seed obtained from dealers. These results may simply be connected with the frequently observed fact that a healthy strong crop is much less liable to be damaged by insects than one which is weakly. There is a very wide field for study in what exactly constitutes healthiness or otherwise in plants and what physiological changes take place which attract insect pests to them or enable them to multiply. Until a chemist can be found to work on this subject it must to a large extent remain a mystery. The future of the control of many pests is, however, largely bound up with this problem, which will involve both chemical and botanical research. There appears to be no reason why insect-resistant crops should not be evolved in the same way as fungus-resisting wheat and cane are now being grown.

	Date of examination	Percentage of attack
I. Seed Farm. Coimbatore District ..	9-11-IV-21	7·5
II. „ „ „ ..	9-11-IV-21	7·0
III. „ „ „ ..	9-11-IV-21	7·5
IV. „ „ „ ..	9-11-IV-21	6·5
Raiyats' field adjoining I	....	17·5
„ „ same area	....	22·0

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